relating to the supply of electricity be transferred. It recommends that the existing system of generating electricity for small areas be abolished. One of the first duties of the Electricity Commissioners would be to divide the country into districts technically suitable for the generation and distribution of electricity. In each district an Electricity Board is to be set up, which will purchase all the generating stations in it. These Electricity Boards are to be financed in whole or in part with Government assistance, and are to make no divisible profits. The Committee laudably strives to conciliate those authorities and engineers who are adversely affected by its proposals. It claims, however, extended powers for the use of overhead wires, wayleaves, and the acquisition of water rights. From the practical point of view the proposals are good, and their adoption, provided that they could be smoothly carried out, would be greatly in the national interests. We hope that Parliament will give to these proposals its most serious consideration.

THE EDUCATION BILL.

THE debate on clause 10, the most important feature of the Education Bill, was resumed in Committee of the whole House on Wednesday, June 5, and continued on June 10 and 11. Sir H. Hibbert submitted, at the instance of many Lancashire Members, an alternative scheme to that of the Bill, whereby, at the option of the local authority, half-time between fourteen and sixteen years of age and thenceforward no compulsory scheme of continued education might be substituted for the proposal in the Bill to require between the ages of fourteen and eighteen a maximum of 320 hours in each year to be included within the ordinary working hours. Mr. Fisher opposed the amendment on the ground that it could not be made mandatory over the whole country, that it would seriously reduce wages, introduce confusion into administration, and would practically double the demand for teachers and for school accommodation. To the great disappointment of many friends of the measure, and especially of this important and vital feature of it, Mr. Fisher, in response to representations not only on behalf of the textile industry, but also in respect of agriculture and of coal-mining, submitted amendments to section i. of clause 10 reducing the compulsory hours in each of the four years from 320 to 280, if the local authority so resolve, and providing that the obligation to attend continuation schools shall not, within the period of seven years from the appointed day on which the provisions of clause 10 (i.) come into force, apply to young persons between the ages of sixteen and eighteen. The Lancashire Members thereupon withdrew their opposition, and Mr. Fisher's amendments were adopted, together with an amendment leaving the local authority free to deal with the times and seasons best suited to the circumstances of each locality. Difficulties of buildings, equipment, and the supply of teachers had doubtless something to do with this decision, but the great advantage gained by the concession is permanently to secure the educational oversight of the adolescent until he reaches the age of eighteen. On Monday Mr. Fisher accepted an amendment by which it was agreed to establish a national scheme for training boys who desire to enter the mercantile marine. Sir Philip Magnus moved to amend subsection 2 in such a way that the recognition of a school as efficient by a British university, equally with such recognition by the Board of Education, should make full-time attendance in that school up to the age of sixteen years a ground of exemption from the obligation to attend continuation schools. After discussion the amendment was withdrawn, and Mr. Fisher agreed to substitute for the words "under arrangements approved by the Board of Education" the words "under regulations made by the inspecting body after consultation with the Board of Education."

It was suggested in the discussion on Tuesday that pressure might be brought to bear upon young persons to attend continuation schools at or in connection with their place of employment. An amendment was afterwards accepted against any such compulsion by a local authority without the consent of the young person or his parents. Clause 10 was finally agreed to as amended.

LIGHT AND VISION.[1]

THE phenomena which take place between the incidence of light on the cornea and the mental appreciation of the fact may conveniently be divided into three stages:—

(1) The production of an image on the retina by means of the dioptric system of the eye. This is purely a physical question, and has been very completely worked out. The only component of a physiological nature is the mechanism of accommodation, by which the curvature of the lens is changed in order to vary the focal length of the system. It would appear that the muscular mechanism here involved is liable to fatigue, and doubtless plays its part in the choice of appropriate methods of illumination, as in the tests used by Ferree.[2] It will also be plain that insufficient illumination requires more exact and tiring accurate adjustment of focus.

(2) When light arrives at the particular layer of the retina known as that of the rods and cones, it excites a photo-chemical change of some kind, which in its turn acts upon the terminations of the optic nerve-fibres and sends along these fibres a series of disturbances which we call nerve impulses.

(3) Arriving at the brain, these impulses are distributed to a complex system of centres composed of nerve-cells, where processes occur associated, in some mysterious way, with the conscious perception of light and illuminated objects.

We naturally ask the question:—What kind of sensation do we experience if the optic nerve is stimulated in other ways, as can be done by means of sufficiently powerful agents? The answer is that whatever be the way in which the optic nerve is stimulated, the sensation is one of light. This statement applies, altering light for sound, taste, etc., to all the nerves of special sense, and is commonly known as Müller's law. In point of fact, it had been formulated by Sir Chas. Bell at an earlier date, though perhaps in not so complete a form. The sensation, then, is an affair of the brain, the "cerebral analysers," as Pavlov calls them, and provided that this part of the brain is set into activity, it matters not by what means, the sensation is the same. This again applies to all the special senses. What, then, is the function of the elaborate structure at the peripheral end of the nerve? Such organs are known in general as "receptors," and their function may be grasped if we try to stimulate the optic nerve by throwing a beam of light upon it. Nothing happens at all, because the nerve-fibres are not responsive to light energy. Some sort of mechanism that is affected by this form of energy must be provided, and is to be found in the rod and cone layer of the retina.

But what is passing along the optic nerve when a light sensation is experienced is identical with that passing along the auditory nerve when a sound is heard.

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[1] Abridged from a paper read at the meeting of the Society of Illuminating Engineers on April 16 by Prof. W. M. Bayliss, F.R.S.

[2] Trans. Illumin. Engineer. Soc. (U.S.A.), vol. viii., p. 40, and Ferree and Rand, *ibid.*

In addition to the rod and cone layer, the retina of the vertebrate contains several layers of nerve-cells. These do not really belong to the receptor organ itself, but are probably of the nature of relays. In the cuttle-fish they form a separate mass, outside the eye itself.

We know that the cones are sensitive to light, because they are the only elements present in the most sensitive spot of the retina, the fovea centralis. That of the rods is more disputed, but their nervous connections are similar to those of the cones, so that it is difficult to believe that they are not also receptors for light.

The only satisfactory explanation of the mode of stimulation of the retina by light is that it is through the intermediation of a chemical reaction brought about by radiant energy of a limited series of wavelengths. As yet only one substance sensitive to light has been discovered in this situation. This is usually known as "visual purple," but its actual colour would be described by most people as deep rose red.

Remembering, in the first place, Grotthus's law, that light can produce an effect only in proportion as it is absorbed, it is of importance to investigate the absorbent properties of visual purple as regards that part of the spectrum which is visible to us. This has been done by Victor Henri and Larguier des Bancels.[3] They determined the absorption of light by solutions of visual purple, compared it with the degree of chemical action, and also with the minimal amount of light energy required to excite a just perceptible sensation from the peripheral parts of the retina. The determinations were made throughout the visible spectrum, and the three curves show a remarkable agreement. These facts show that visual purple is at least the most important photo-chemically sensitive component of the retina, if not the only one. We note also that there are no absorption bands in its spectrum, so that there is no difficulty with respect to colour vision. An interesting fact comes out from the curve of sensibility of the retina compared with the energy of the light acting. At that particular frequency of vibration corresponding with the yellow-green, the threshold of stimulus coincides with the energy quantum of Planck for that rate of vibration. In other words, the retina is sensitive to as small an incidence of energy as it is possible for it to receive.

Very little is known as to the chemical nature of visual purple. It exists in colloidal solution in a liquid in which the rods and cones are immersed. Although it is not produced in the fovea itself, Dr. Edridge-Green has found evidence that it flows in from surrounding parts.

The best information to be obtained of the course of the photo-chemical reaction is obtained from records of the electrical changes which occur on the incidence of light. The simpler curve given by the eye of the cuttle-fish is to be regarded as indicating the essential part of the phenomenon; the more complex form of the vertebrate curve is probably due to the presence of the extraneous nerve-cells. The chief points to be noticed are the following:—

First, the curve gradually falls, the stimulus merely disappears, on the advent of darkness. There is no indication of a stimulus of any kind produced by darkness. This is contrary to the well-known theory of Hering, according to which the reaction of restoration, occurring when the light ceases, is associated with a positive sensation of darkness. This point of view had been applied to physiological phenomena in general, but is now practically given up.

Secondly, the curve, after it has attained its maximum, remains constant while the illumination lasts.

Thirdly, the reaction does not attain its full intensity suddenly, nor do the products disappear suddenly. In other words, the sensation does not appear at once, nor does it immediately disappear when the stimulus ceases. This is the obvious explanation of the absence of flicker when the alternations of light and darkness are sufficiently rapid. Further, as would be expected from a chemical reaction, the greater its magnitude, the longer it requires for the products to recombine or otherwise disappear. Incidentally, the form of the curve differs somewhat for different colours.

Fourthly, there is a short latent period between the time of incidence of light and the electrical effect. If this is not counterbalanced by a similar period after the illumination ceases, it would result in some deviation from Talbot's law in its physiological aspect, such as has been described by Parker and Patten. The latent period reminds us of the "photo-chemical induction" of Bunsen and Roscoe.

There is reason to believe that the maximum sensibility of the fovea is not when it is the only part of the retina illuminated, but when there is simultaneously a weak illumination of the surrounding parts. This seems to be connected with the production and movement of the visual purple. If it be the fact, its importance in observations with the microscope, the polarimeter, and other optical instruments is obvious.

The explanation of positive and negative after-images is fairly plain—the former by the products of photo-chemical change not disappearing at once, the latter by temporary exhaustion of the visual purple. Edridge-Green[4] has shown that the situation and shape of the positive after-image can be altered by jerking the head, showing that the chemical change is located in the liquid surrounding the rods and cones. Hence these structures must be affected secondarily. The negative after-image is fixed, indicating a situation in the more solid parts of the receptive mechanism.

The adaptation of the retina to various degrees of illumination—an important fact in daily life—is probably due to a change in the position of the pseudo-equilibrium which results from the fact that the products of a reversible photo-chemical reaction are continually recombining during the illumination itself. The circumstance that this adaptation is not a very rapid process is of importance in relation to the practical aspect of artificial illumination, and shows that sudden changes in the lighting of neighbouring objects are not desirable. The suggestion that the ratio of brightness of objects to which the eye turns should not exceed 1 : 100 seems a reasonable one.

The problem of "glare" is also connected, although the fact of the unpleasant and injurious effect of powerful local stimulation of the retina has also to be taken into account. But, like so many of the practical problems we meet with, it requires much more investigation, and the co-operation of the physiologist, the illuminating engineer, the oculist, and the factory inspector is much to be desired.

The effect of lateral illumination brings up the question of the function of the rods as distinct from that of the cones, as do also vision under weak illumination and that known as "night-blindness." The first problem has been very able treated by Dr. Herbert Parsons in a Home Office report, while the enormous range of intensity of the light perceived has been emphasised by Mr. Trotter. This degree of "adaptation" is much greater than could be accounted for by varying apertures of the pupil.

The question of the colour of the light in relation to fatigue has been brought to my notice. According to Ferree's observations, either a yellow or a blue tint is more fatiguing than a white light. The difficulty of a satisfactory test for fatigue of the visual mechanism arises here, and we have to deal with a very complicated set of factors. Many of the tests used seem to indicate muscular fatigue either of the extrinsic eye muscles or of the mechanism of accommodation. Moreover, the large question of general fatigue is involved. Tests such as those used by Dr. Stanley Kent would give valuable information as to the effects of various systems of illumination, and especially as to what are to be regarded as defective. It may be pointed out that the present conditions are unusually favourable to investigations of this kind in factories under Government control. An equally important series of questions has been raised by Mr. Gaster, namely, the effect on school children with normal and with imperfect vision of working in adequate light. Data on all these points would be of great value.

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[3] V. Henri et J. Larguier des Bancels, *Journ. de Physiol. et Pathol.* ol. xiii., pp. 841–56 (1911).

[4] *Journ. of Physiol.*, vol. xlv., p. 70.

Whatever may be the precise results obtained from such investigations, there can be no doubt that children should not be compelled to do their home-work in bad lighting conditions, however necessary it may be to effect a saving in the consumption of gas and electric current. A more widely spread diffusion of information as to ways in which saving may be effected without injurious results is much to be desired.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Cambridge.—A memorandum emphasising the urgency of making formal provision for the encouragement of the study of geodesy and geodynamics in the University, and recommending the early establishment of a readership in these subjects if a suitable endowment can be obtained, has been submitted by the Special Board for Mathematics to the General Board of Studies. The latter has reported that it fully concurs in the importance of the early establishment of such a readership. In its memorandum the Special Board gives reasons why special provision and formal recognition for geodesy and geodynamics is particularly called for at the present time in the University. The progress on the theoretical side of the science of the figure of the earth has been promoted in the past very largely by investigators belonging to Cambridge in connection with the scientific problems presented both by the British and by the Indian Surveys, trigonometrical and gravitational. More recently the interconnection of the Surveys of different nations has made the subject an international one, and for the last twenty years the headquarters of the International Geodetic Association, supported by subventions from the various Governments, has been at Potsdam. Reconstruction is called for in the near future, and this country ought to be in a position to resume a large share in the direction. The establishment of a British Imperial Geodetic Institute, with State endowment, is now being urged by responsible scientific bodies, and some institution of the kind will be necessary. Whatever arrangements may be made on the technical and administrative side, the theoretical side, which is the foundation of all progress, is a subject of pure mathematical and dynamical science, and can best be advanced by the universities. In order for Cambridge to retain her historical position in the advance of this important science, and to take part in the training of the men who will be required for its prosecution, some special provision and formal recognition for the subject are called for under modern conditions.

Oxford.—On June 8 a numerous company assembled in the Sheldonian Theatre to hear Mr. Asquith deliver his Romanes lecture on the Victorian age. The chair was occupied by Lord Curzon of Kedleston, Chancellor of the University, who took occasion to denounce "the gross and gratuitous defamation of the character of our public men." Mr. Asquith, after speaking of the financial and commercial activity which formed one of the chief characteristics of the Victorian age, and the prominence of the novel among the literary productions of the time, went on to offer a brief appreciation of the most famous names in the period under review. Towards the end of his discourse he touched upon the great scientific movements initiated by Victorian chemists, physicists, and biologists, selecting for special mention Faraday, Kelvin, and Darwin. Disclaiming all qualification to speak as an expert, or to hold the balance between antagonistic views as to the method of evolution, he nevertheless paid tribute to the spirit of single-minded investigation manifested by Darwin and to the unselfish and generous manner in which Wallace had minimised his own merits as a co-discoverer with Darwin of the principle of natural selection. The celebrated retort by Huxley upon the ill-judged attack of Bishop Wilberforce was once more related before an Oxford audience, and Mr. Asquith ended by declaring his own conviction that, whatever man's physical pedigree, he had reached a stage in development which raised him into an essentially different category from that of other living beings, and endowed him with qualities which could only be appreciated and expressed by "the poet who had the gift of vision."

On June 11, the anniversary of the burial of Roger Bacon within the precincts of the Grey Friars at Oxford, the first visitation took place of the memorial tablet which was affixed to the city wall in October, 1917.

Mr. P. L. Bernstein, of the Municipal College of Technology, Manchester, has been appointed lecturer in electrical engineering at the Hull Technical College.

A holiday course in psychology, arranged for teachers and others, is to be held at Bedford College for Women, Regent's Park, from August 1 to 10 inclusive It will include lectures on psychological topics, and afford opportunities for individual laboratory work. Particulars are obtainable from the Principal of the College.

Two Chadwick public lectures on "Our Fisheries and the Food Supply" will be delivered in London by Prof. D'Arcy Wentworth Thompson on June 21 and 28, at 5 p.m. The first lecture, on "The Catch by Line and Trawl," will be given at the Mansion House, and the second, on "The Catch by Net, or the Great Herring Fishery," at the Surveyors' Institution, Westminster. Admission will be free. Further particulars of these and other Chadwick public lectures may be obtained of the Secretary at the offices of the Trust, 40 (6th) Queen Anne's Chambers, Westminster.

The serious shortage in the supply of teachers for elementary schools is again dealt with in the Report of the Board of Education for the year 1916–17 (Cd. 9045), which is now available. The total number of boys and girls beginning in 1917 to train for the career of teaching was 6158, as compared with 6544 in 1916, and 9614 in 1908. From 1908 there was a steady decline down to 1912 in the number of entrants, when it had fallen to 5232. This was followed by a period of recovery, the number reaching 7047 in 1915, since which date it has steadily fallen again. The imme-